Cured-in-place pipe

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A **cured-in-place pipe** (CIPP) is one of several trenchless rehabilitation methods used to repair existing pipelines. CIPP is a jointless, seamless, pipe-within-a-pipe with the capability to rehabilitate pipes ranging in diameter from 0.1–2.8 meter (4"–110"). As one of the most widely used rehabilitation methods CIPP has application in water, sewer, gas, and chemical pipelines.[1]

Contents

The CIPP Process

A resin-saturated felt tube made of polyester, fibreglass cloth or a number of other materials suitable for resin impregnation, is inverted or pulled into a damaged pipe. It is usually done from the upstream access point (manhole or excavation). It is possible to invert the liner upstream (e.g. from the downstream access point) but this carries greater risk. It is possible to install a liner from the downstream access point, upstream to a blind end however this carries the highest risk of all the CIPP installation methods. Little to no digging is involved in this trenchless process, making for a potentially more cost-effective and less disruptive method than traditional "dig and replace" pipe repair methods. The liner can be inverted using water or air pressure. The pressure required for inversion can be generated using pressure vessels, scaffolds or a "Chip unit". Hot water, UV light, ambient cured or steam is used to cure the resin and form a tight-fitting, jointless and corrosion-resistant replacement pipe. Service laterals are restored internally with robotically controlled cutting devices in the larger diameter pipe. Smaller diameters (100mm) can be opened remotely however they are often reinstated by excavation. These can be sealed with additional seals into the lateral connection (Lateral Junction Repair) or T-Liner. The resin used is typically polyester. Since all resins shrink and it is impossible to bond to a sewer that has fats, oils, and grease an annular space exists between the new CIPP liner and the host pipe. The annular space exists in all installations just some are larger than others. The most effective way to prevent water from tracking in the annular space and entering back into the waste stream is through gasket sealing technology. Gaskets made from water swelling material (hydrophilic) can be placed at the ends of the host pipe and at the lateral connections. ASTM F2561 is the current industry standard for main to lateral connection lining by cured in place method. The rehabilitated pipe is then inspected by closed-circuit television (CCTV). CIPP is considered a trenchless technology.

History

In 1971, Eric Wood implemented the first cured-in-place pipe technology in London, England. He called the CIPP process *insitu form*, derived from the Latin meaning "form in place." Wood applied for U.S. patent no. 4009063 on January 29, 1975. The patent was granted February 22, 1977 and was commercialized by Insituform Technologies until it entered the public domain on February 22, 1994.

Advantages

As a trenchless technology, CIPP does not require excavation to rehabilitate a pipeline that is either leaking or structurally unsound. Depending upon design considerations an excavation may be made, but the liner is often installed through a manhole or other existing access point. Anything larger than 60" must be excavated in order to install. Liner is installed as it is wet out on site in these instances. In the case of sewerlines, lateral connections are also restored without excavation via a remote controlled device that drills a hole in the liner at the point of the lateral connection. If larger than 24" and it is safe to do so someone will reinstate laterals by hand. CIPP has a smooth interior and no joints. While CIPP can repair a pipe with bends, special design considerations must be taken into account to prevent wrinkling and stretching. CIPP can effectively reduce infiltration and leaks in pipeline systems without digging.

Disadvantages and Limitations

Except for very common sizes, liners are not usually stocked and must be made specifically for each project.[1] CIPP requires bypass of the flow in the existing pipeline while the liner is being installed. The curing may take from one hour to 30 hours depending on pipe diameter and curing system (steam / water / uv) and must be carefully monitored, inspected, and tested. Obstructions in the existing pipeline, such as protruding laterals, must be removed prior to installation. Cost should be compared with similar methods such as Shotcrete, thermoformed pipe, close-fit pipe, spiral wound pipe and sliplining as these other methods can provide a similar design solution for similar or less cost in certain situations. CIPP must also be carefully monitored for release of chemical agents utilized in the reaction process for contamination downstream of rehabilitated pipes. The liner material used for common sizes is normally a felted fabric (non-woven) and does not go around bends well without wrinkling and going out of round on corners. Liners used for pipes with bends (particularly 100 mm pipes) are made from a woven fabric allowing it to go around bends with minimal wrinkling. The more flexible the liner, the more care needs to be taken during inversion to ensure the liner remains on the correct alignment. Once a line is repaired with the CIPP method, that line can no longer be cabled or snaked with a machine, it must be cleaned by method of Hydro jetting (AKA. high pressure water blasting)

Quality Assurance & Quality Control

Testing of CIPP installations is required to confirm that the materials used comply with the site and engineering requirements. Since ground and ambient installation conditions as well as crew skills can affect the success or failure of a cure cycle, testing is performed by 3rd party laboratories in normal cases and should be requested by the owner.

Samples should be representative of the installation environment since the liner is installed in the ground. Wet sandbags should be used around the restraint where the test sample will be extracted from. As with any specimen preparation for a materials test, it is important to not to affect the material properties during the specimen preparation process. Research has shown that test specimen selection can have a significant effect on the CIPP flexural testing results. Test specimens for ASTM D790 flexural testing must meet the requirements of ASTM D790.

The North American CIPP industry has standardized around the standard ASTM F1216 which uses test specimens oriented parallel with the pipe axis, while Europe uses the standard EN ISO 11296-4 with test specimens oriented in the hoop direction. Research has shown that flexural testing results from the same liner material are usually lower when determined using EN ISO 11296-4 as compared to ASTM F1216.

Environmental, Public Health, and Infrastructure Incidents

Testing conducted by the Virginia Department of Transportation (http://www.virginiadot.org/) and University researchers (http://www.southce.org/ajwhelton/) from 2011-2013 showed that some CIPP installations can cause aquatic toxicity.[2] A list of environmental, public health, and infrastructure incidents caused by CIPP installations as of 2013 was published by the Journal of Environmental Engineering (http://ascelibrary.org/doi/abs/10.1061/(ASCE)EE.1943-7870.0000662). In 2014, University researchers (http://www.southce.org/ajwhelton/) published a more detailed study in Environmental Science & Technology (http://pubs.acs.org/doi/abs/10.1021/es5018637) that examined CIPP condensate chemical and aquatic toxicity as well as chemical leaching from stormwater culvert CIPP installations in Alabama. [3] In this new report additional water and air environmental contamination incidents were reported not previously described elsewhere. With proper engineering design specifications, contractor installation procedures, and construction oversight many of these problems can be prevented.

References

1. Mohammed Najafi, PhD, PE and Sanjov Gokhale, PhD, PE, *Trenchless Technology* (New York: McGraw Hill, 2004), p. 295–311. Available from Water Environment Federation at http://www.e-wef.org/timssnet/static/OM/WPM404.htm.
2. Whelton, A.J., Salehi, M., Tabor, M., Donaldson, B., and Estaba, J. (2013). ”Impact of Infrastructure Coating Materials on Storm-Water Quality: Review and Experimental Study.” J. Environ. Eng., 139(5), 746–756.
3. Tabor, M.L., Newman, D., Whelton, A.J. (2014). ”Stormwater Chemical Contamination Caused by Cured-in-Place Pipe (CIPP) Infrastructure Rehabilitation Activities.” Environ. Sci. Technol. In press.

External links

- New research on CIPP published by a scientific journal: [1] (http://ascelibrary.org/doi/abs/10.1061/(ASCE)EE.1943-7870.0000662)
- Information on U.S. Patent no. 4009063: [2] (http://patft.uspto.gov/netacgi/nph-Parser?u=%2Fnetahtml%2Fsrchnum.htm&Sect1=PTO1&Sect2=HITOFF&p=1&r=1&l=50&f=G&d=PALL&s1=4009063.PN.&OS=PN/4009063&RS=PN/4009063)
- Related information on CIPP patents:[3] (http://www.patentstorm.us/patents/5736166-description.html)
- Trenchless Technology: [4] (http://www.trenchlessonline.com/pdfs/06_magazines/prg_all.pdf)
- How CIPP is installed: [5] (http://www.insituform.com/content/190/how_insituform_cipp_is_installed.aspx)
- North American & European Test Methods - Impact on CIPP Flexural Properties: [6] (http://www.paragonsystems.ca/wp-content/uploads/2013/01/3-6-Niagara-Falls-June-2012-Paragon-Systems.pdf)
- The effect of test specimen selection on the flexural testing of CIPP [7] (http://www.paragonsystems.ca/wp-content/uploads/2013/01/CERIU_INFRA_2012_Paragon_Systems-web.pdf)
- Water quality and aquatic toxicity impacts of CIPP sites from the ASCE Journal of Environmental Engineering: Whelton, A., Salehi, M., Tabor, M., Donaldson, B., and Estaba, J. (2013). ”Impact of Infrastructure Coating Materials on Storm-Water Quality: Review and Experimental Study.” J. Environ. Eng., 139(5), 746–756.